Indian J. Phys. **75B** (3), 215–216 (2001)

I J P B
— an international journal

Waveguide T junction circulator at Ka-band

Satish Kumar* and R P Dixit
Defence Electronics Applications Laboratory, Raipur Road, Dehradun-248 001, Uttaranchal, India

Abstract Even though design aspects of circulators [1,2] have been described in detail by many authors, there was still a need to evolve a simple and direct approach by examining various advantages and disadvantages of these methods This paper is a step in this direction. The paper also gives the practical performance of circulators designed at Ka-band of frequencies adopting the methodology described.

Keywords Power divider, Ka-band, design of phase and gain.

PACS No. 84 40.Az

1. Introduction

Extensive published literature is available on the theoretical design aspects of wave-guide circulators. Various practical geometries of mounting the ferrite have been qualitatively and quantitatively dealt [3–5]. A simple and effective methodology for design of circulators was still required as the practical design/fabrications considerations dictate the best geometry suitable for given specification and the frequency of operation.

2. Design considerations/steps

(i) Specify the max/min tolerable VSWR at reach port. VSWR is related to admittance.

Phase angle θ as [4]

$$\text{VSWR} = Y_r^2/G_r^2 = \sec^2\theta.$$

(ii) Calculate Q_L loaded Q of the cavity from [4]

$$Q_L = \tan\theta/\{(f_1 - f_2)/f_0\},$$

where f_1 and f_2 are the extreme frequencies of operations and f_0 is mid band frequency.

(iii) Q_L, the loaded Q of the cavity is related to the amount of counter rotating mode frequency splitting as [4].

$$K/\mu = 0.71/Q_L$$

where K and μ are components of Tensor permeability for the ferrite used.

(iv) Decide operating region *i.e.* below resonance or above resonance.

(v) Decide saturation magnetization $4\pi M_s$ value of the ferrite suitable for the use.

(vi) Calculate the disc radius as [4]

$$r = 1.84\lambda/2\pi\sqrt{(\mu_{\text{eff}}.\varepsilon_r)},$$

where $\mu_{\text{eff}} = \{1-(\gamma^2 M_0^2/\omega^2)\} \approx 1 - K^2$, $\gamma = 2.8\,\text{MHz/Oe}$, M_0 is the ferrite magnetization and ω is the operating frequency.

(vii) Diameter of the ferrite disc is $d = 2r$.

(viii) If triangular ferrite is used, side of the ferrite triangle a is given by

$$a = 2\sqrt{3}r,$$

(ix) If a single matching triangle is used for matching waveguide impedance to the ferrite the length of matching equilateral triangle side l can be calculated as

$$l = a + (\sqrt{3}\lambda_g)/4,$$

where λ_g is the guide wavelength.

(x) The suitable value of the thickness d of the ferrite can be chosen by the relation

$$0.7 < d/b < 0.85 \text{ [4]},$$

where b is the height of the waveguide.

* Corresponding Author

3. Results

The y-junction circulator has been designed using the design steps described above. Matching triangle has been fabricated as integrated part of the cavity with the help of the CNC machine. The ferrite TT-86-6000 from Trans Tech USA has been used in the circulator. Practical results are shown in Figure 2. Figure 1 shows the split block view of the circulator

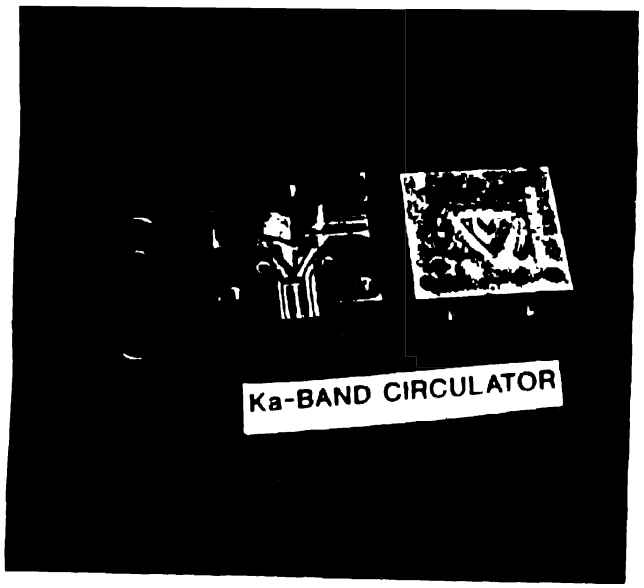

Figure 1.

cavity. The assembled circulator has been tested with the help of Network Analyzer HP 8510C. Figure 2 shows the VSWR, insertion loss and isolation between the ports of circulator. VSWR < 1.2, insertion loss 0.3 to 0.5 dB and isolation greater than 20 db have been achieved on all the ports for a band width of 3 GHz

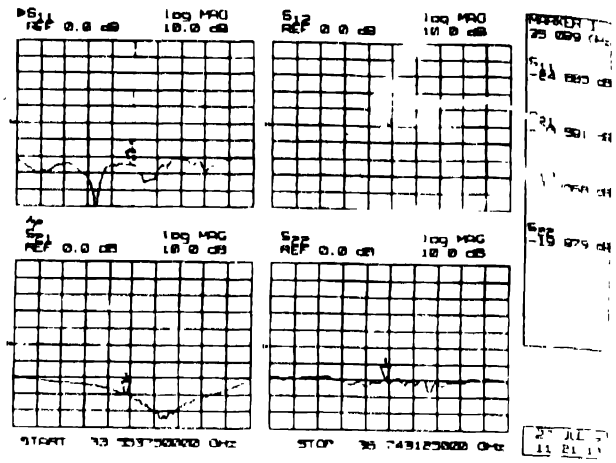

Figure 2.

Acknowledgments

The authors are grateful to Dr. A S Bains, Director, DEAL, Dehradun for allowing this work to be published. Authors are also thankful to Mr. P P Marwaha, Head, CAME Center and Mr. V P Dutta for the fabrication of circulator cavities with integrated matching triangles. Finally, they would like to express their thanks to Mr. Balbir Singh for the assembly of circulators.

References

[1] E N Skomal *IEEE Transaction of Microwave Theory and Technique* p 117 (1963)

[2] J Helszajn *Principles of Microwave Ferrite Engineering* (London . John Wiley)

[3] L Thourel *The Use of Ferrite at Microwave Frequencies* (Translated by J B Arthur) (London Pergamon)

[4] D K Linkhart *Microwave Circulator Design* (Norwood, MA Artech House) (1989)

[5] R F Soohoo *Theory and Application of Ferrites* (Englwood Cliffs NJ Pentice Hall) (1960)